
Preface

Since introduction of the Scanning Tunnelling Microscope (STM) by inventors G. Binnig and H. Rohrer in 1981 at the IBM Zurich Research Laboratory, Rüschlikon, Switzerland., many variations of tip probe based microscopies, referred to as Scanning Probe Microscopies (SPM) have been developed. Nanoscale Science and Technology are strongly driven by SPMs which allow investigation and manipulation of surfaces down to the atomic scale. While the pure imaging capabilities of SPM techniques dominated the application of these methods at their early development stages, the physics of probe-sample interactions and the quantitative analyses of elastic/plastic, tribological, electronic, magnetic, biological, and chemical surfaces have now become of increasing interest. With growing understanding of the underlying interaction mechanisms, SPMs have found applications in many fields outside basic research fields. In addition, a variety of derivatives of all these methods has been developed for special applications, some of them targeting far beyond microscopy.

For industrial applications, the large SPM-subfamily of Scanning Force Microscopy (SFM) exhibiting atomic resolution capability is of special interest. Originally denoted as Atomic Force Microscopy (AFM), the basic instrument was invented by G. Binnig, C. Quate and Ch. Gerber in 1986. The introduction of this technique was a direct consequence of the observation of sizable interaction forces between a near field probe and a sample surface which were already seen in earlier experiments done with Scanning Tunnelling Microscopy (STM). STM experiments performed, for example, on HOPG-graphite surfaces, indicated a strong influence of elastic surface properties on the measured surface corrugation which could not be traced back to electronic surface properties. Based on these types of results it appeared quite natural to introduce a method that is solely based on tip-sample force interactions rather than transport phenomena such as electron tunnelling as used in the STM. The AFM was the first purely force sensitive microscope. Its applicability on electrically insulating surfaces opened a wide range of applications. In addition, this method can also be applied under various environmental conditions, such as vacuum, air and liquids. Thus, a wide variety of applications including industrial quality control and the investigation of living biological materials became feasible with high resolution, and without any conductive coatings. Since for many practical applications atomic resolution is not the ultimate and only goal, the family of commercial instruments which measure forces is more generally referred to as Scanning Force Microscopes (SFM). While in the beginning of SFMs, high resolution measurement of surface topography was the major

application, it became clear very soon, that by applying more complex strategies, i.e. dynamic and lateral force techniques the quantitative measurement of local material properties also became possible. Beyond that, the local measurement of the distribution of locally varying electrical surface potentials and magnetic stray fields became accessible – altogether properties of great practical interest. Therefore, it appears quite natural that SFM related techniques play a major role in industrial applications today including topographic and dynamical surface studies such as of semiconductors, polymers, paper, ceramics, magnetic and biological materials.

Commercial production of SPMs started with STM in 1988 and has grown to several hundred million dollars industry. The number of these instruments is equally divided among the U.S., Japan and Europe with the following industry, university and government laboratories split: 50/50, 70/30, and 30/70, respectively.

This book selects some representative recent applications of SPM with a focus on practical applications. While not necessarily limited to SFM, the general applicability and variability of this method in industrial research and quality control led to a natural focus as reflected in the large number of chapters dealing with SFM related techniques. Selected articles on the application of near field optical and capacitance techniques for novel storage applications put a special focus on industrial R&D based on these techniques. The organization of the book is straightforward. The book is divided into three parts. Part I contains chapters dealing with the theoretical background of static and dynamic force microscopies including sensor technology and methods for tip characterization. Part II contains chapters on applications of scanning force microscopy such as micro- and nanotribology, polymer surfaces, stray field measurements and roughness investigations. The last Part III contains a selection of articles mainly written by industrial researchers. Examples for special application of SFM such as atomic manipulation and surface modification are presented. Furthermore, novel concepts for high resolution optical storage techniques as well as for the production of single electron devices based on SFM are presented.

The purpose of this book is to give both, a systematic physical and technical background for the academic researcher on recent progress of applied scanning probe microscopy and an overview of the current state of SPM applications for the industrial researcher and engineer. We hope that readers find this book stimulating and productive.

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